NATURAL HISTORY MISCELLANEA

Published by

The Chicago Academy of Sciences

Lincoln Park - 2001 N. Clark St., Chicago 14, Illinois

No. 127 February 9, 1954

Observations on the Reproduction and Distribution of the Green Snake, *Opheodrys vernalis* (Harlan)

W. T. Stille*

The discovery of natural nests of green snakes in the Chicago region during the years 1940 and 1941 indicated differences between local populations of this species and those of northern Michigan studied by Blanchard (1933) . This was particularly true in the case of egg-laying dates. Numerous discussions of these and related matters with Dr. **H.** K. Gloyd led to the acquisition of additional data for subsequent years and to this report.

It now appears there is a relationship between climatological effects and green snake reproduction and that the former may be used to predict dates of oviposition. The differences in egg-laying dates noted from year to year in the Chicago region and also in northern Michigan may be accounted for by temperature differences. Moreover, the differences in egg-laying dates between local populations and those of northern Michigan are wholly explicable in terms of climatological dissimilarities. Average May temperatures were implicated as being most closely associated with oviposition and hatching dates.

As a kind of test of the tenability of the May temperature relation to green snake reproduction, extrapolations were made from this relation to obtain the temperatures necessary to expect eggs to be laid in May (or April) . It became apparent that green snakes were not found in localities where this prediction could be tested. Proceeding along this line, it appeared that the range of the green snake could be descriptively defined as being generally north of the average 64° F. isothermal zone for May (the eastern race being further limited to north of the 61° F. isothermal zone) .

* Present address: Saunders Road, Lake Forest, Illinois.

Identity of Chicago Region Green Snakes. Taxonomically the green snakes of the Chicago region are intergrades between *Opheodrys vernalis vernalis (* Harlan) and *0. v. blanchardi* Grobman, having slightly greater affinities toward the latter. During the past ten years, eggs and gravid females, which later laid eggs, were collected in three areas in the immediate vicinity of Chicago. These areas are descriptively designated as north, west, and southwest. In terms of scutellation there is no evidence to suggest that snakes from these areas are not samples from the same homogeneous population, and hence they will be considered as such. Scutellation data are summarized in Table I, along with portions of Grobman's data (1941, p. 23) .

Table I. The mean number of ventral scales of green snakes.

Specimens from:	Males	Females
North of Chicago	128 (1)*	141.8 ± 1.5 (5)
West of Chicago	130.6 ± .81 (27)	142.0 ± .57 (27)
Southwest of Chicago	132.9 ± .58 (7)	141.8 ± .79 (8)
Total for Chicago	131.0 ± .66 (35)	141.9 ± .44 (40)
Characteristic of the races (Grobman, 1941):		
O. v. vernalis	123.7 ± .24 (203)	132.1 ± .25 (268)
O. v. blanchardi	134.4 ± .54 (31)	144.5 ± .66 (31)

* Number of specimens is indicated parenthetically. Each mean is accompanied by the standard error of the mean.

Collecting Areas. The north and southwest areas are open grassy fields in which houses are irregularly and sparsely placed. New houses are frequently added, construction work appearing to be continuously in progress. Specimens from these areas have been procured almost entirely by disturbing the abundant litter consisting of building material and assorted rubbish, mainly during daylight hours. No eggs or empty shells have been found here. Two independent reports obtained in both areas, as a result of a number of brief conversations, seem to indicate that eggs of the green snake are occasionally deposited under rusting cans.

The west area was a field adjacent to railroad tracks and bounded on the other three sides by wooded Forest Preserves. Ties of a former railroad siding lay parallel to, and about 100 feet from, the serviceable tracks. Building materials and rubbish in much lesser quantities than present in other fields were distributed throughout the area. Since 1942 broken concrete, and later rubbish, have been dumped there and this site has now become rather depopulated.

Natural Nests and Characteristics of *Eggs.* Five dry eggshells were found in the west area in a partly buried railroad tie during mid-August in 1940. The eggs had been laid on dirt within the cleaving tie. On the 10th of July in 1941 about eight sets of eggs were found. One set had

been deposited under a board at the edge of the dry dirt road; the other sets were found under and in the moist crevices of rotting ties. The occurrence of two sets of eggs laid together (at least in space) in one tie was observed twice. It is assumed that these two aggregates were composite on the basis of numbers of eggs (ten and fifteen per group) , an indication of bimodality in hatching dates, and the fairly large size of the eggs *(egg* length seems to be negatively correlated with the number of eggs in a set) . It was not possible, however, to partition these aggregates into their supposed two complements with any degree of certainty. Ten days later another set of eggs was found under a six-inch section of a railroad tie. These eggs were laid after my first visit to that area. Adult green snakes were found in and under these ties on most occasions. In this as well as at the other areas, a garter snake *(Thamnophis radix)* was encountered much more often than the green snake.

During the years 1942, 1946, 1948, and 1949, adult females were taken at various times from early June to August and confined in isolation. This resulted in the deposition of eleven sets of eggs, only a very small portion of which were allowed to develop to hatching.

Measurements of 97 eggs from the Chicago region gave a mean length of 21.9 ± .39 mm. and a mean diameter of 10.4 ± .13 mm. *Egg* data from northern Michigan, obtained from Blanchard's Figure 51 (1933, p. 496) on 199 eggs, give a mean length of 24.8 ± .34 mm. and a mean diameter of 12.0 ± .14 mm. The significantly larger size of eggs from northern Michigan as compared with that of the Chicago region is reminiscent of Bergmann's rule for warm-blooded animals. Measurements of 23 recently hatched green snakes gave a mean of 133.5 ± 2.5 mm., which is significantly larger than Blanchard's measurements on 136 young in Table 57 (p. 505) with a mean of 125.1 ± .85 mm. The hatching size of the young thus fits the inverse of Bergmann's rule for poikilothermic animals. *Egg* teeth were not noted in young of the Chicago region.

In addition to the 41 sets of eggs studied, Blanchard notes the number of eggs per set on 12 additional clutches from northern Michigan (p. 498) . The mean number of these 53 sets is 6.7 ± .24. Similar data from the Chicago region, including dissections and a nest of shells, give an average of 5.8 ± .39 *eggs* for 25 sets. This difference of about one *egg* is not statistically significant, but it is in the same direction that is, an increase in eggs per nest from south to north, as noted in widespread bird species.

Dates of Egg Deposition and Hatching. The average date of egg deposition in the Chicago region (Table II) was the 16th or 17th of July, with a range from the 24th of June to the 31st of July. Including data for natural nests, the average egg-laying date is before the 14th

of July for a total of nineteen sets of eggs. In northern Michigan, the average *egg* deposition date was the 10th of August with a range from the 24th of July to the 29th of August (Table III) . Hence, there is a difference of about a month between the average dates observed for these two localities.

Table II. Dates of egg deposition for Chicago region *Opheodrys v. vernalis* x *blanchardi* counted from June 1st.

Year	Oviposition dates	Mean
1942	40, 48, 50, 50, 50, 50	48.0
1946	41, 45	43.0
1948	53, 61	57.0
1949	24	24.0

Table III. Dates of egg deposition for northern Michigan *Opheodrys v. vernalis* counted from June 1st.*

Year	Oviposition dates	Mean
1924	70, 72, 79, 86, 86	78.6
1925	76, 77, 69, 78	75.0
1926	64, 67, 68, 75, 75	69.8
1927	78, 83, 90	83.7
1928	—, —	
1929	69, 76, 79	74.7
1930	54, 55, 59, —, 64, 65, —, —, —, —, —	59.4
1931	—, 56, 58, 64, —, 66, 67, —	62.2

* Blanchard's original order of enumerating the sets of eggs is maintained in Tables III and IV. The dashes in Table III indicate the natural nests without definite dates of deposition. An exception is set number 34, indicated by the dash for the first entry in Table III for the year 1931. These eggs were laid on the 16th of July under circumstances which Blanchard considered abnormal. Hence this datum was not used. Where egg-laying or hatching extended over a period of several days, the average of the extreme dates, to the nearest integer, is recorded in the table. No significance is attached to June 1st. Any other date would serve just as well as a base from which days to oviposition and hatching could be counted.

An analysis of the variance of the data in Table II and the data in Table III indicates, in both cases, that the variability of the *egg* deposition dates between years is relatively much too large to be reasonably explained by accidents of sampling. The ***F*** ratios for these two samples, both statistically significant at the 1 per cent level, are 14.87, with 3 and 7 degrees of freedom, and 10.71 with 6 and 23 degrees of freedom, respectively. Since green snakes were collected in the Chicago region from June through August, and Blanchard's notes indicate a similar collecting period in northern Michigan, it seems that the differences between years are not primarily due to differences in collecting activity.

Twenty-eight Chicago region eggs were permitted to develop to hatching from the supposed nine sets of field eggs found in 1941. These eggs had the 10th of August as an average hatching date with at least

a month between hatching and deposition. The *eggs* were kept in a mixture of moist sawdust and sand and experienced considerable temperature variation. In northern Michigan the average date of hatching was about the 21st of August with approximately one-third of a month

Table IV. Hatching dates for northern Michigan *Opheodrys v. vernalis* counted from June 1st.

Year	Hatching dates	Mean
1924	93, 93, 96, 90, 95	93.4
1925	81, 90, 81, 89	85.3
1926	82, 85, 82, 84, 87	84.0
1927	91, 92, 96	93.0
1928	86, 90	88.0
1929	89, 97, 87	91.0
1930	68, 71, 73, 69, 80, 84, 72, 67, 70, 67, 67	71.6
1931	72, 74, 75, 78, 72, 84, 87, 79	77.6

between hatching and deposition. An analysis of the variance of the hatching data in Table IV similarly indicates statistically significant differences among the dates of different years yielding an F ratio of 17.93 with 7 and 33 degrees of freedom. While there seems to be a tendency toward ovoviviparity in the more northern populations of the green snake, hatching data from sets of eggs deposited and incubated in the laboratory under varied conditions form a poor basis for estimating missing information for natural conditions in the field. A similar statement would seem to be true for data on *egg* deposition; however, there is no indication of the female being affected by the length of time in captivity, so far as dates of egg-laying go.

May Temperatures and Oviposition Dates. From a routine examination of monthly rainfall and mean temperature data for those months preceding oviposition and hatching, it was found that the mean temperature of May (defined by the Weather Bureau as the mean of the averages of the daily extreme temperatures) seems to show the closest simple relation to green snake reproduction. In Figure 1 the years for which green snake *egg* data are available are arranged along the abscissa according to the mean May temperatures for each particular year. Dates of average *egg* deposition and hatching, counted from June 1st, are plotted on the ordinate for the corresponding years. Most of these data appear in Tables II, II, and IV. (Arrows on symbols indicate the use of dates of finding natural nests of eggs. Hence, mean dates of *egg* laying should be plotted an uncertain number of days earlier.)

The linearity of laying dates with respect to May temperatures is self evident, but hatching dates seem to show a discontinuity between northern Michigan and Chicago. The early September record for emergence of young, based on field observations of Siebert and Hagen (1947, p. 20)

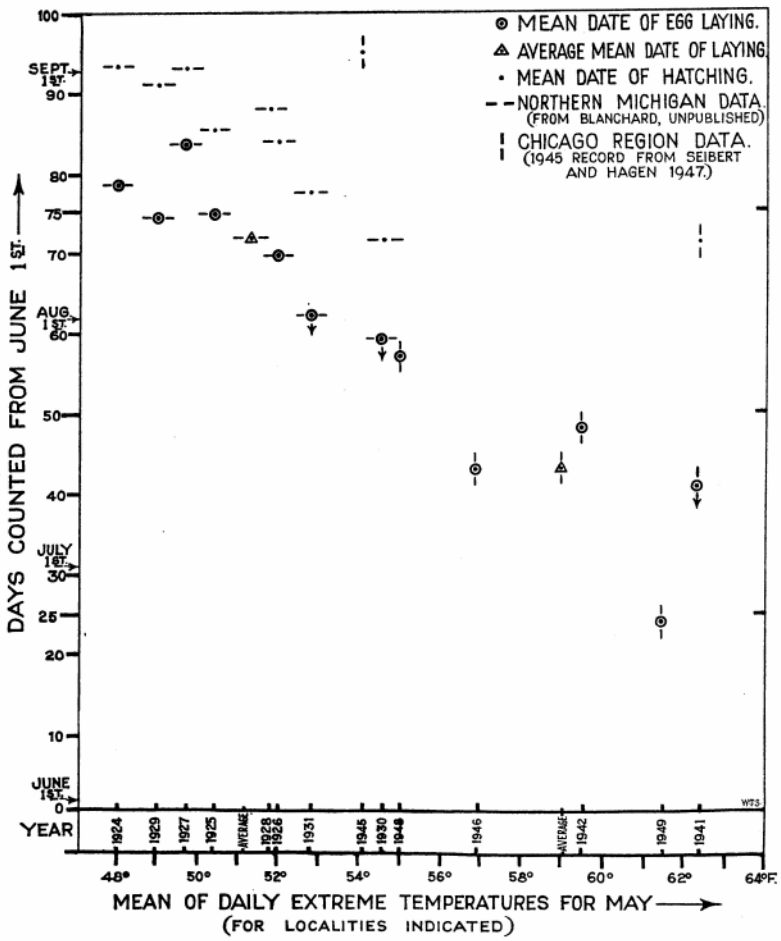

Figure 1. The relation of May temperatures to egg-laying and hatching of *Opheodrys vernalis* at Chicago and in northern Michigan.

south of Chicago, is included in Figure 1. As they suggest, the lateness of this record "must be considered the result of a cold April and May." Because of the meager hatching observations for the Chicago region, there is, as yet, no evidence to indicate that the northern Michigan trend in hatching dates as related to May temperatures is continuous to the Chicago region; there is, rather, some indication of discontinuity.

The weather data for northern Michigan used in Figure 1 are for the town of Cheboygan. Douglas Lake, the site of Blanchard's work, is about

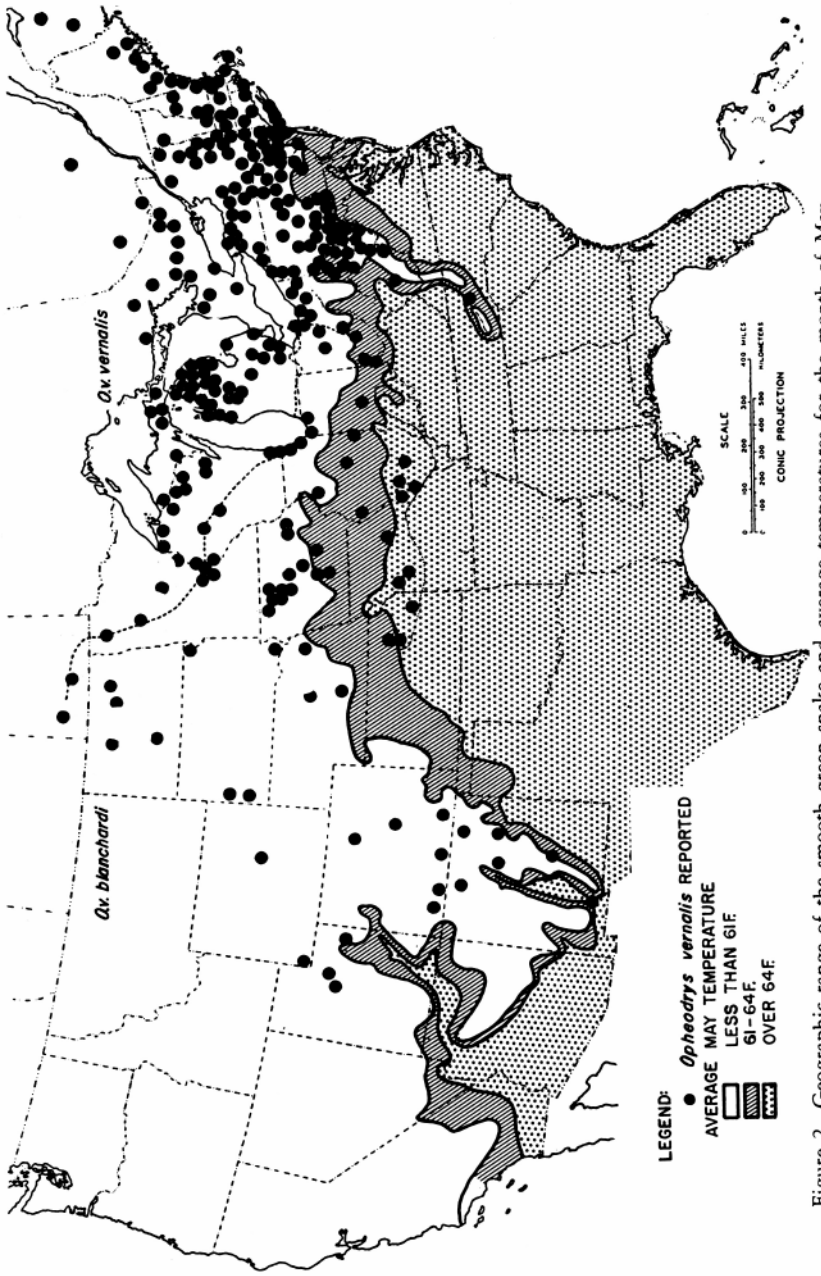

Figure 2. Geographic range of the smooth green snake and average temperatures for the month of May.

eleven miles southwest of Cheboygan. Since 1942, weather data have become available for the town of Pellston, about four miles distant from Douglas Lake. On the basis of seven years of available observations there is no evident difference between the average May temperatures of Pellston and Cheboygan. The correlation between their average May temperatures was found to be r — .85. Hence, it would seem that climatological data for Cheboygan can be used to approximate that of Douglas Lake.

Temperature and rainfall of other months seem to be associated with oviposition and hatching. Prominent among these, but of much less importance in comparison to May temperature, is the apparent connection between June rainfall and egg-laying dates. However, until more data have accumulated, the lesser effects of June rains, also more difficult to interpret, must remain as yet unestablished.

Distribution and May Temperature. As was mentioned above, green snakes appeared to be absent from areas of high average May temperatures. The average May isotherms for Figure 2 were plotted on Grobman's map (1941) of green snake locality records to permit selection of the "best fitting" isotherm. The weather data are based on the average May temperatures computed through 1949 of over 1000 stations concentrated primarily in the region of the southern periphery of the range of the green snake. While the general isothermal configurations of several other months resemble those for May, they do not fit the distribution as well in all details over the entire range of this species.

It appears that the eastern form, *Opheodrys v. vernalis,* lacks locality records south of the 64° F. isotherm with only nine county records within the 61° F. 64° F. zone. The western form, O. *v. blanchard,* has twenty-three county records south of the 61° F. isotherm. Of these, about nine seem to be areas near but above the 64° F. isotherm. None of the green snake locality records edited by Grobman seem to be from areas averaging 65° F. or over during May.

A relation between isotherms and locality records is unexpected for a number of reasons. The temperature data used are for air temperatures taken at least six feet above the ground. Such data would not be expected to have a uniform relation to ground temperatures as one moves through many environments across the country. Terrain features related to climatic modification and distant from weather stations, particularly in the critical areas near the 64° F. isotherm, could be expected to produce effects in what appears to be a continuum of one temperature type and so confuse the relations. Because the length of station records varies, isotherms may have peculiar bends not because of temperature differences of proximal localities, but because of historical differences in the dates of establishing the stations. Hence, it would seem more reasonable to presume that

temperature *per se* is not important. Some correlated or indirect effect is more closely connected with the causative aspects of this relation.

Discussion. We have available the fact that reproductive dates of green snakes can be predicted by average May temperature. It appears that certain average May isotherms and the southern limits of the range of the green snake coincide. The studies of Siebert and Hagen (1947) corroborate the writer's observations that green snakes seem to have a limited home range, and, since they are not migratory, they are most readily obtained where they nest. Thus, it seems preferable to call Grobman's " natural range" (1950) the reproductive range of the green snake.

Since June or July temperatures (months of *egg* incubation) offer no apparent means of predicting reproductive dates, the main temperature effects evidently do not operate by advancing or retarding rates of development. It would seem, therefore, that the effect of average May temperature is to vary the time of *initiation* of the developmental process of reproduction. (Of course we cannot overlook the fact that since we are dealing with a correlation, other effects correlated with temperature may influence green snakes. It would be well then to consider average May temperatures only as a *kind* of data.)

A report by Dymond and Fry (1932) suggests green snake matings in the fall. It still may be that fertilization of the *eggs* occurs in the spring. Should subsequent observations or experiments not confirm this, effects correlated with, but other than, May temperature must be sought to explain the means by which the timing of green snake reproduction is achieved.

With the data at hand, we can go no further. One might speculate that some physiological calamity more frequently befalls the green snake reproductive process as higher average May temperatures are encountered. In this way the species is limited in its distribution to the south. If such a calamity occurs, it will necessarily be established on additonal data.

Summary. The green snakes of the Chicago region are intergrades between *Opheodrys v. vernalis* and *O. v. blanchardi* with greater affinities toward the latter.

Eggs or shells of this population have been found in and under rotting railroad ties under conditions similar to those of northern Michigan described by Blanchard. Other eggs were obtained from captive gravid females.

The eggs were found to be smaller in the Chicago region, but the young at hatching were larger than those of northern Michigan. The

number of eggs per set eventually may be found to be somewhat less in the Chicago region.

The eggs observed were laid about a month earlier in the Chicago region, i.e., in early July. Hatching occurred in the laboratory about a month after oviposition; in northern Michigan the similar period, according to Blanchard, was about one-third of a month.

Early oviposition dates appeared to be associated with higher average temperatures for the month of May, presumably due to advancing the date of initiation of development rather than accelerating the developmental processes.

The southern limit of the reproductive range of the green snake lies in or near the average isothermal zone between 61° to 64° F. for the month of May.

It is suggested that the green snake is limited to the south by high average May temperature through reproductive failure.

Acknowledgements. The author wishes to acknowledge the aid of R. A. Edgren, E. J. Lace, L. Stern, Lois Stille, Patricia Thomas, and E. J. Tierney. Prof. Sewall Wright of the University of Chicago, Prof. Orlando Park of Northwestern University, and Dr. Howard K. Gloyd of the Chicago Academy of Sciences have made suggestions. Through the kindness of Dr. Gloyd original unpublished notes of the late Dr. F. N. Blanchard were made available to the writer.

Literature Cited

Blanchard, Frank Nelson

1933 Eggs and young of the smooth green snake *Opheodrys vernalis* (Harlan) . Papers Michigan Acad. Sci., Arts and Let., vol. 17, p. 493-508, *fig.* 51-57, pl. 51-56.

Dymond, J. R. and F. E. J. Fry

1932 Notes on the breeding habits of the green snake *(Liopeltis vernalis)* . Copeia, no. 2, p. 102.

Grobman, Arnold B.

1941 A contribution to the knowledge of variation in *Opheodrys vernalis* (Harlan) , with a description of a new subspecies. Misc. Pub. Mus. Zool., Univ. Mich., no. 50, p. 1-38, *fig.* 1-2, map 1.

1950 The problem of the natural range of a species. Copeia, no. 3, p. 231-232.

Siebert, Henri C. and Charles W. Hagen

1947 Studies on a population of snakes in Illinois. Copeia, no. 1, p. 6-22, *fig.* 1-10.

U. S. Department of Commerce. Weather Bureau.
1923-49 Climatological Data (By Sections) .

NATURAL HISTORY MISCELLANEA

Published by

The Chicago Academy of Sciences

Lincoln Park - 2001 N. Clark St., Chicago 14, Illinois

Natural History Miscellanea, a series of miscellaneous papers more or less technical in nature, was initiated by The Chicago Academy of Sciences in 1946 as an outlet for short, original articles in any field of natural history. It is edited by the Director of the Academy with assistance from the Scientific Governors' Committee on Publications and other qualified specialists. Individual issues, published at irregular intervals, are numbered separately and represent only one field of specialization; e.g., botany, geology, entomology, herpetology, etc. The series is distributed to libraries and scientific organizations with which the Academy maintains exchanges. Title pages and indexes are supplied to these institutions when a sufficient number of pages to form a volume have been printed. Individual specialists with whom the Academy or the various authors maintain exchanges receive those numbers dealing with their particular fields of interest. A reserve is set aside for future exchanges and a supply of each number is available for sale at a nominal price. Authors may obtain copies for their personal use at the prevailing rates for similar reprints.

When citing this series in bibliographies and in preparing abstracts, authors are requested to use the following preferred abbreviations: *Chicago Acad. Sci., Nat. Hist. Misc.*